

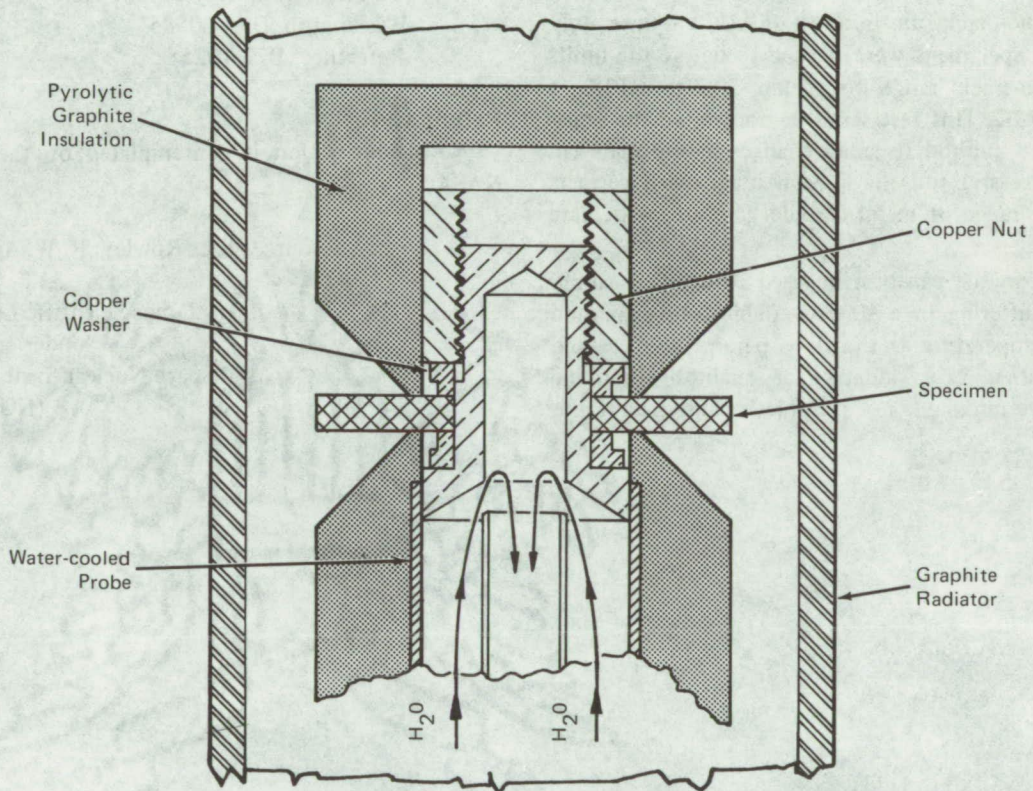
NASA TECH BRIEF

Space Nuclear Systems Office



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Repeatable Method of Thermal Stress Fracture Test of Brittle Materials



The problem:

The thermal stress testing of graphite for the Nuclear Rocket required a simple reliable method of qualifying one sample against another with high accuracy. No test existed in which fracture is caused solely by a temperature gradient under steady-state conditions. One test method involved a temperature gradient, but a mechanical load was also needed. Another method utilized electric arc shock-induced stress; the specimen abruptly fractured completely rather than cracking. Both of these techniques were not acceptable.

The solution:

A method has been devised in which specimens are heated slowly and with sufficient control so that the critical temperature gradient in the specimens cannot occur before temperature equilibrium is reached, i.e., during the transient phase.

How it's done:

The test apparatus consists of a water-cooled copper probe for mounting the specimen, and a surrounding furnace containing a resistance heated graphite radiator.

(continued overleaf)

The probe is insulated with pyrolytic graphite. The specimen is held in place by an integral shoulder of the probe, and kept in intimate contact with the probe by two copper washers. Each specimen is examined for manufacturing flaws before test, and again for thermally induced cracks after test, using an eddy current device which will readily detect even the smallest crack and a dye penetrant which will not only detect any crack, but also establish its size and shape.

The object of a test is to find the radiator temperature at which the first crack is initiated. In a typical test a temperature is estimated at which fracture should occur, and the radiator is ramped-up to that value, usually in about five minutes. After ramp-down, the specimen is examined. If a crack has occurred, the radiator temperature for the next specimen is lowered arbitrarily to establish a no-crack run. In a test of AUC graphite, only four to six specimens were needed to define the limits of crack/no-crack range to within 303 to 313K at around 2673K. This test series demonstrated the sensitivity of the method to small changes in the material. Similar successful runs have been made with cermets and a wide range of metal carbide graphite particulate composites.

This technique can best be used to compare similar materials differing in a single variable. The maximum radiator temperature is the only parameter measured; however, it is very valuable for qualitative ranking. Quantitative ranking is not possible because many other

factors which can contribute to cracking cannot be measured. The test fixture is uncomplicated and durable. The specimen geometry is simple and easy to fabricate, and the test results are readily reproducible and sensitive enough to detect component changes such as flour size.

Notes:

1. A wide variety of testing laboratories should find this method attractive in the evaluation of brittle coatings, linings of large furnaces, turbine and reentry body design, carbide machine tool fabrication and other related products
2. Requests for further information may be directed to:
Technology Utilization Officer
AEC-NASA Space Nuclear Systems Office
U.S. Atomic Energy Commission
Washington, D.C. 20545
Reference: B72-10258

Patent status:

No patent action is contemplated by the AEC or NASA.

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